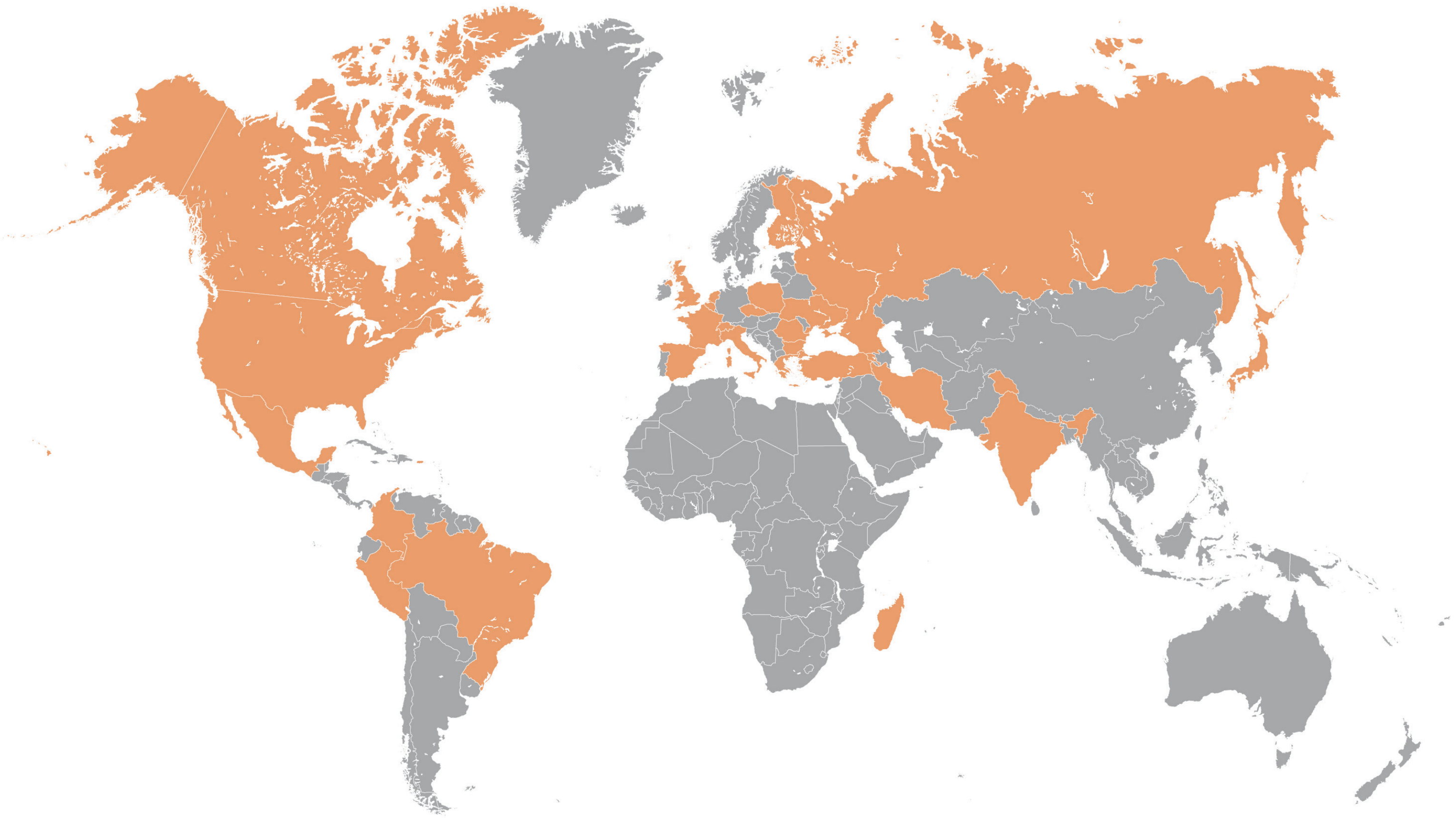
International collaboration

About 800 scientists from approximately 150 institutions in 27 countries collaborate on the Deep Underground Neutrino Experiment. Collaborators encourage and anticipate further international participation.

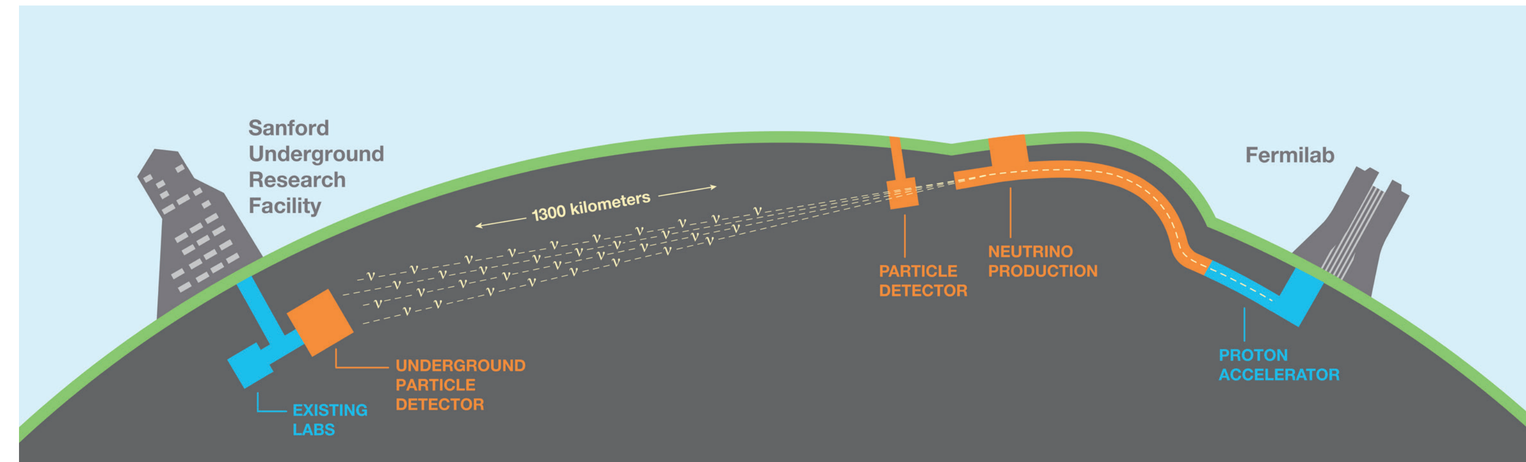


List of countries and participating institutions

Armenia Yerevan Inst. for Theoretical Physics and Modeling
Belgium Univ. de Liege
Brazil Univ. Federal do ABC; Univ. Federal de Alfenas em Poços de Caldas; Univ. de Campinas; Univ. Estadual de Feira de Santana; Univ. Federal de Goias; Observatorio Nacional
Bulgaria Univ. of Sofia
Canada York University
Colombia Univ. del Atlantico
Czech Republic Charles University, Prague; Czech Technical University, Prague; Institute of Physics ASCR, Prague
Finland Univ. of Jyvaskyla
France Lab. d'Annecy-le-Vieux de Phys. des Particules; Inst. de Physique Nucleaire de Lyon; APC-Paris; CEA/Sacla
Greece Univ. of Athens
India Aligarh Muslim University; Banaras Hindu University; Bhabha Atomic Research Center; Univ. of Delhi; Indian Inst. of Technology, Guwahati; Harish-Chandra Research Institute; Indian Inst. of Technology, Hyderabad; Univ. of Hyderabad; Univ. of Jammu; Jawaharlal Nehru University; Koneru Lakshmaiah; Univ. of Lucknow; Panjab University; Punjab Agri. University; Variable Energy Cyclotron Centre
Iran Inst. for Research in Fundamental Sciences
Italy Lab. Nazionali del Gran Sasso, Assergi; Univ. di Catania; Gran Sasso Science Institute; Univ. di Milano; INFN Sezione di Milano Bicocca; INFN Sezione di Napoli; Univ. of Padova; Univ. of Pavia, INFN Sezione di Pavia; CNI Pisa; Univ. di Pisa
Japan KEK; Kavli IPMU, Univ. of Tokyo
Madagascar Univ. of Antananarivo
Mexico Univ. de Colima; CINVESTAV
Netherlands NIKHEF
Peru PUCP
Poland Inst. of Nuclear Physics, Krakow; National Centre for Nuclear Research, Warsaw; Univ. of Warsaw; Wroclaw University
Romania Horia Hulubei National Institute
Russia Inst. for Nuclear Research, Moscow
Spain Inst. de Fìsica d'Altas Energias, Barcelona; CIEMAT; Inst. de Fisica Corpuscular, Madrid
Switzerland Univ. of Bern; CERN; ETH Zurich
Turkey TUBITAK Space Technologies Research Institute
Ukraine Kyiv National University
United Kingdom Univ. of Cambridge; Univ. of Durham; Univ. of Huddersfield; Imperial College of Science, Tech. & Medicine; Lancaster University; Univ. of Liverpool; University College London; Univ. of Manchester; Univ. of Oxford; STFC Rutherford Appleton Laboratory; Univ. of Sheffield; Univ. of Sussex; Univ. of Warwick
USA Univ. of Alabama; Argonne National Lab; Boston University; Brookhaven National Lab; Univ. of California, Berkeley; Univ. of California, Davis; Univ. of California, Irvine; Univ. of California, Los Angeles; California Inst. of Technology; Univ. of Chicago; Univ. of Cincinnati; Univ. of Colorado; Colorado State University; Columbia University; Cornell University; Dakota State University; Drexel University; Duke University; Fermi National Accelerator Lab; Univ. of Hawaii; Univ. of Houston; Idaho State University; Illinois Institute of Technology; Indiana University; Iowa State University; Kansas State University; Lawrence Berkeley National Lab; Los Alamos National Lab; Louisiana State University; Univ. of Maryland; Massachusetts Institute of Technology; Michigan State University; Univ. of Minnesota; Univ. of Minnesota (Duluth); Univ. of New Mexico; Northwestern University; Univ. of Notre Dame; Ohio State University; Oregon State University; Pacific Northwest National Lab; Univ. of Pennsylvania; Pennsylvania State University; Univ. of Pittsburgh; Princeton University; Univ. of Puerto Rico; Univ. of Rochester; SLAC National Accelerator Lab; Univ. of South Carolina; Univ. of South Dakota; South Dakota School of Mines and Technology; South Dakota Science And Technology Authority; South Dakota State University; Southern Methodist University; Stanford University; Stony Brook University; Syracuse University; Univ. of Tennessee; Univ. of Texas at Arlington; Univ. of Texas at Austin; Tufts University; Virginia Tech; Wichita State University; College of William and Mary; Univ. of Wisconsin; Yale University

Deep Underground Neutrino Experiment

A game-changing particle physics experiment, with support from more than 800 scientists in 27 countries, aims to transform our understanding of neutrinos and their role in the universe. The first truly international mega-science facility hosted in the United States by the Department of Energy would make it possible.



The proposed Long-Baseline Neutrino Facility would send neutrinos straight through the earth from Fermilab in Batavia, Illinois, to the Sanford Underground Research Facility in Lead, South Dakota. Scientists would use the neutrino beam for the proposed Deep Underground Neutrino Experiment.

Mysterious neutrinos

Neutrinos are among the most abundant particles in the universe, a billion times more abundant than the particles that make up stars, planets and people. Each second, a trillion neutrinos from the sun and other celestial objects pass through your body. Although neutrinos are all around us, they interact so rarely with other matter that they are very difficult to observe.

The latest developments in particle accelerator and detector technology make possible promising new experiments in neutrino science. The Deep Underground Neutrino Experiment collaboration, which comprises about 800 scientists from 27 countries, has proposed to build a world-leading neutrino experiment that would involve construction at both Fermi National Accelerator Laboratory (Fermilab), located in Batavia, Illinois, and the Sanford Underground Research Facility (Sanford Lab) in Lead, South Dakota.

Why are neutrinos important?

Neutrinos may provide the key to answering some of the most fundamental questions about the nature of our universe. The discovery that neutrinos have mass, contrary to what was previously thought, has revolutionized our understanding of neutrinos in the last two decades while raising new questions about matter, energy, space and time. Neutrinos may play a key role in solving the mystery of how the universe came to consist of matter rather than antimatter. They could also unveil new, exotic physical processes that have so far been beyond our reach.

What do we know about neutrinos?

Neutrinos are elementary particles that have no electric charge. They are among the most abundant particles in the universe.

They are very light. A neutrino weighs at least a million times less than an electron, but the precise mass is still unknown.

In nature, they are produced in great quantities in the sun and in smaller quantities in the Earth. In the laboratory, scientists can make neutrino beams with particle accelerators.

Neutrinos pass harmlessly right through matter, and only very rarely do they collide with other matter particles.

There are three types of neutrinos: electron neutrinos, muon neutrinos and tau neutrinos.

The laws of quantum mechanics allow a neutrino of one type to turn into another one as the neutrino travels long distances. And they can transform again and again. This process is called neutrino oscillation.

Understanding neutrino oscillations is the key to understanding neutrinos and their role in the universe.

The distance between Fermilab and Sanford Lab is 800 miles (1300 kilometers). This is ideal for examining neutrino oscillations with the proposed Deep Underground Neutrino Experiment. Scientists also would use DUNE to look for neutrinos coming from the explosion of a star—a supernova—to discover the formation of a black hole.

The LBNF neutrino beamline at Fermilab

What is LBNF?

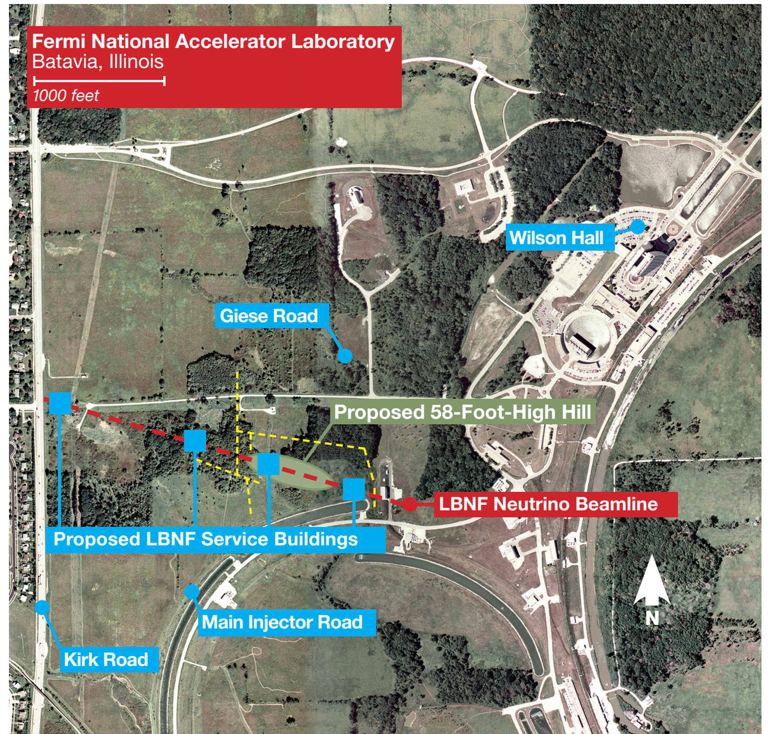
The proposed Long-Baseline Neutrino Facility would use Fermilab's particle accelerators to create neutrinos and send them through the earth to a new, large, cutting-edge neutrino detector located almost a mile underground at the Sanford Underground Research Facility. The neutrinos would travel the 800 miles from Illinois to South Dakota straight through the earth—no tunnel is needed for these particles.

The LBNF neutrino beamline at Fermilab

At Fermilab, scientists have operated neutrino-producing facilities for more than 30 years. The LBNF neutrino beamline would steer protons from Fermilab's Main Injector accelerator up a small hill (see graphic below) and then point the beam into the ground, toward the Sanford Lab. The protons would smash into a piece of graphite. The particles that emerge from these collisions would go into a 680-foot-long tunnel and generate neutrinos that travel in the same direction as the protons. Scientists would also build a state-of-the-art underground hall for the near detector of the Deep Underground Neutrino Experiment. The detector would measure the composition of the neutrino beam as it leaves the Fermilab site.

Traveling at close to the speed of light, the neutrinos would leave the Fermilab site at a depth of about 200 feet, continue straight through the earth and arrive at the Sanford Lab in South Dakota within a fraction of a second. Because neutrinos can travel through rock and all other matter, no tunnel would be necessary for this 800-mile trip.

The DUNE/LBNF team built a 35-ton prototype neutrino detector at Fermilab, using the liquid-argon technology chosen for the construction of the DUNE detector in South Dakota.



The LBNF neutrino beamline and the DUNE near detector would be located on the western part of the Fermilab site, near Giese and Kirk roads in Batavia, Illinois. The locations of the four proposed service buildings are marked with blue squares and the footprint of the proposed, 58-foot-high hill is marked in green. Proposed access roads are marked in yellow. Kirk Road runs along the western boundary of the Fermilab site.

More information

LBNF website: lbnf.fnal.gov

DUNE website: dunescience.org

Fermilab website: www.fnal.gov

For more information contact:
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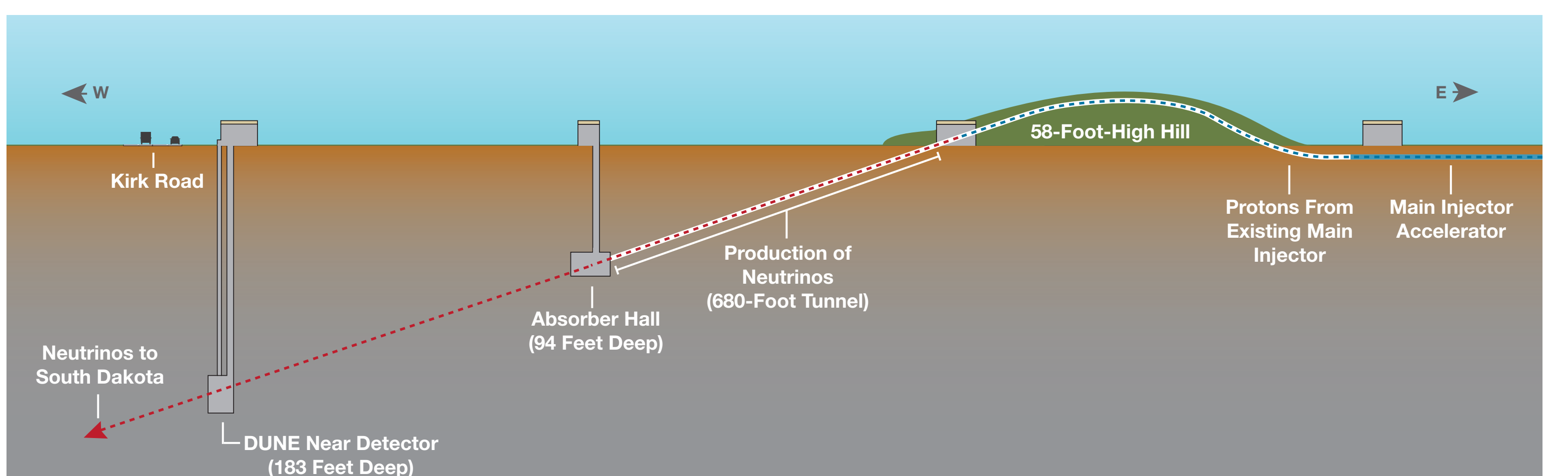
Phone: 630-840-3351 E-mail: katie@fnal.gov
Or send e-mail to the LBNF/DUNE project team:
lbnf-communication@fnal.gov



Scientists plan to use Fermilab's Main Injector accelerator to make neutrinos and send them through the earth to a particle detector in South Dakota. The project proposes the construction of four buildings, a 58-foot-high hill made of compacted soil and a 680-foot-long tunnel on the Fermilab site.

The DUNE particle detector at Sanford Lab

How will DUNE revolutionize neutrino research?

The proposed Deep Underground Neutrino Experiment aims to transform our understanding of neutrinos and their role in the universe. The experiment would measure neutrino oscillations to find out why we live in a matter-dominated universe. DUNE also would look for neutrinos coming from the explosion of a star to discover the formation of a black hole. And DUNE would search for proton decay—particle interactions that would bring us closer to realizing Einstein's dream of a grand unified theory.

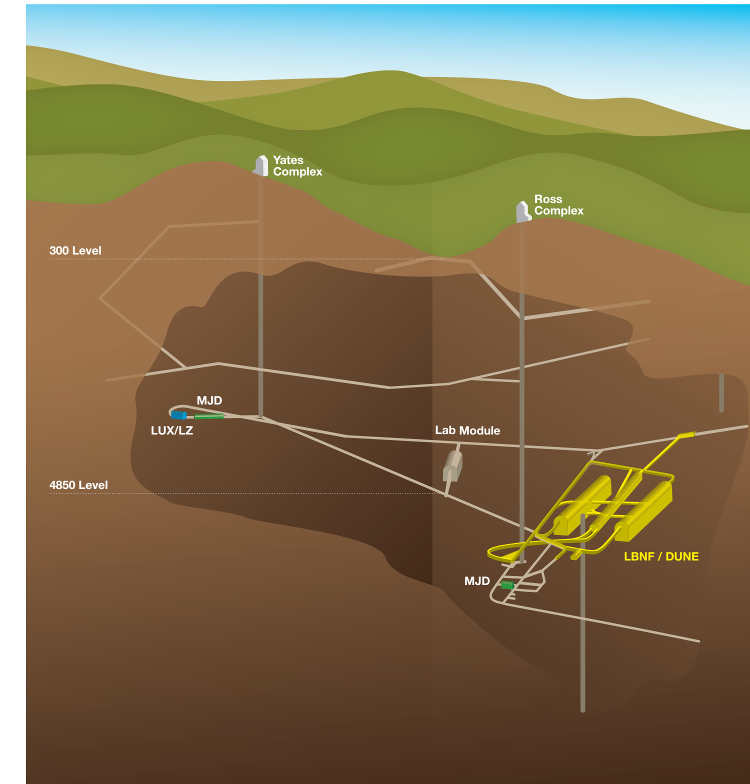
The neutrino detector at Sanford Lab

The proposed DUNE neutrino detector at the Sanford Underground Research Facility would reside in a large underground complex to be excavated by the LBNF project on the 4850-foot level, near the Ross shaft. This deep location would shield the detector from the cosmic rays that bombard the Earth, increasing the detector's capability to identify rare interactions of neutrinos and other particles.

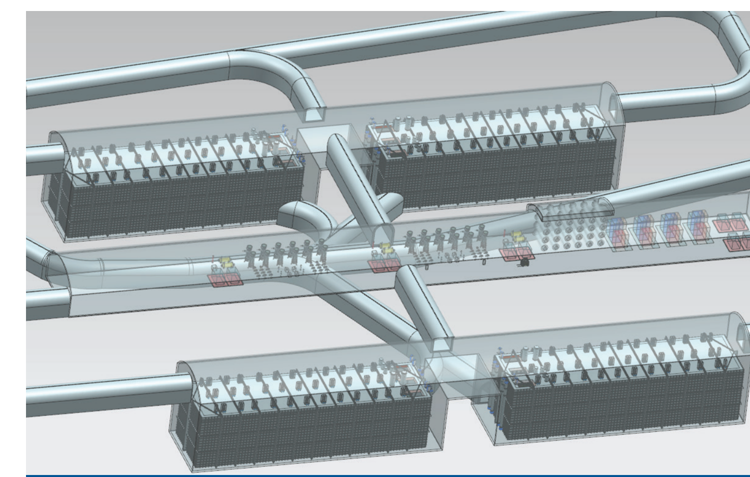
The detector would be filled with almost 70,000 tons of liquid argon, a material similar to helium, but heavier. Like helium, argon must be cooled to remain liquid. Cryogenic equipment would be installed in the cavern to cool argon to minus 303 degrees Fahrenheit.

The particle detector would record the arrival of the neutrinos from Fermilab or the explosion of a star by measuring the rare interactions between neutrinos and the argon atoms. It would transmit the signals to computers for storage and analysis. It would take about a decade to collect enough data to make the hoped-for discoveries that would revolutionize our understanding of the universe.

The far detector of the Deep Underground Neutrino Experiment would be built at the Sanford Underground Research Facility in South Dakota. It would be located in a large cavern to be excavated near the Ross shaft, almost one mile underground.



The proposed DUNE particle detector would be built in a cavern (in yellow) to be excavated near the Ross shaft, on the 4850-level. This deep location would shield the detector from cosmic rays. The neutrinos from Fermilab would travel straight through rock and enter the detector from the east.



Scientists plan to build four detector modules to catch neutrinos from Fermilab and to look for neutrinos from a supernova. Each module would be filled with 17,000 tons of liquid argon.

More information

LBNF website: lbnf.fnal.gov

DUNE website: dunescience.org

Sanford Underground Research Facility website: www.sanfordlab.org

For more information contact:
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Phone: 605-722-4025 E-mail: cwalter@sanfordlab.org
Or send e-mail to the LBNF/DUNE project team:
lbnf-communication@fnal.gov